

(12) UK Patent Application (19) GB (11) 2 130 073 A

(21) Application No 8232227
(22) Date of filing 11 Nov 1982
(43) Application published
31 May 1984

(51) INT CL³
F41H 1/02 B32B 1/04
7/02

(52) Domestic classification
A3V 1A5A 5M2B 7AX 7B1
B5N 0104 0702
U1S 1140 B5N

(56) Documents cited
GBA 2090725
GBA 2061089

(58) Field of search
A3V

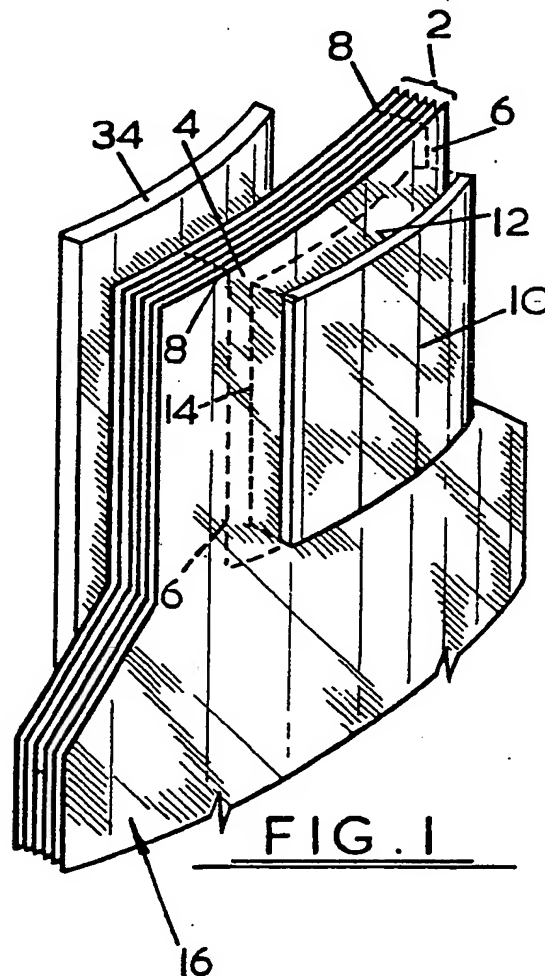
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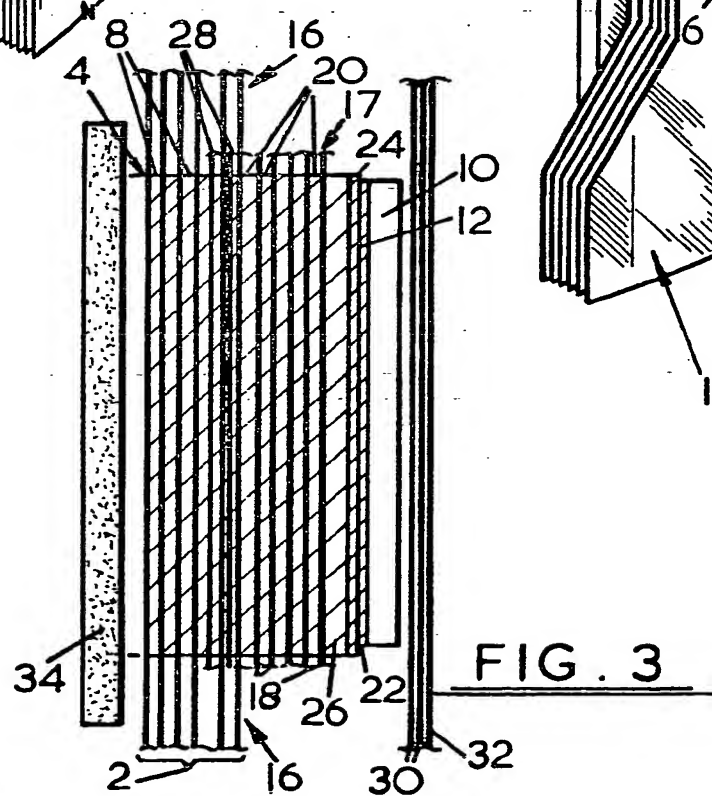
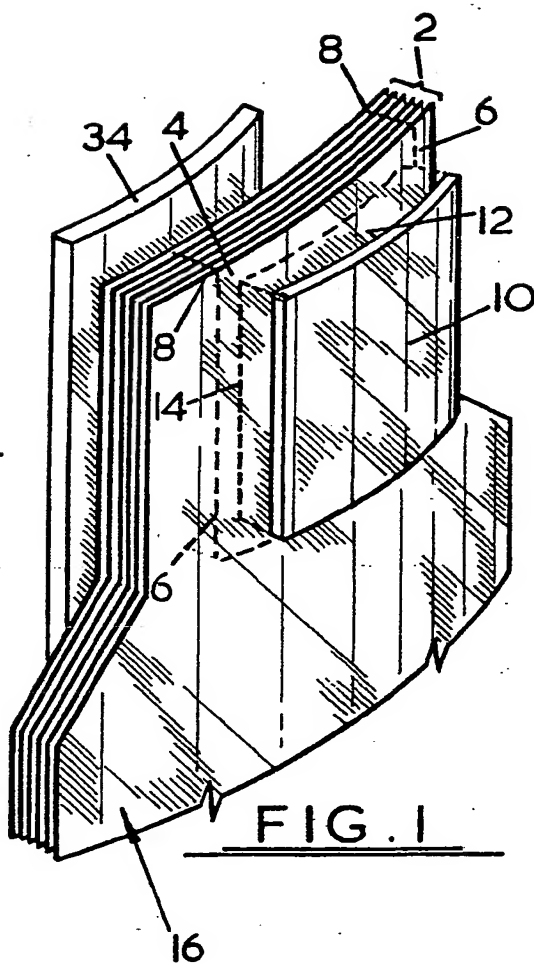
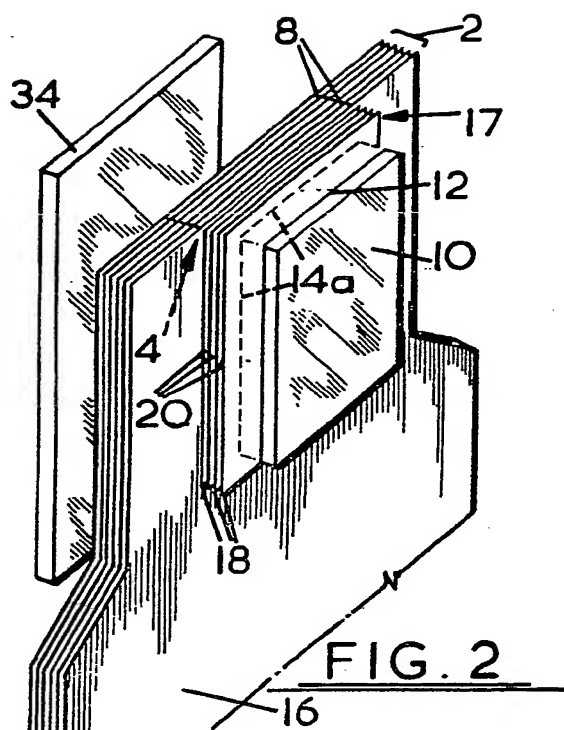
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(54) Protective shield

(57) A protective shield which in use is disposed before a person or thing to be protected from injury by a bullet or other missile, includes a plurality of layers 2 of woven aramid fabric adhesively bonded together at 8 to form a stiff region 4 having an area boundary at 6. At the front of the stiff region 4 an anti-ballistic ceramic tile 10 is bonded thereto so that over the whole of its rear face 12 the tile is supported by the stiff region. If desired an adhesively mounted metal plate and/or an additional stiff support of adhesively bonded aramid or glass fibre layers can be disposed between the region 4 and the tile. The shield can include a trauma pack 34, and be formed as or be incorporated in a garment for wear as body armour.



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SPECIFICATION

Protective shield

This invention concerns a protective shield which in use is disposed before a person or thing to be protected from injury or damage by a bullet or other missile, for example, flying fragments of metal or other hard material.

The invention has a particular but not exclusive application to protective shields forming body armour which is in the nature of clothing, sometimes called bullet-proof clothing.

Known body armour comprises superposed layers of anti-ballistic textile fabric which in the nature of clothing is flexible and adapts to the body shape of the person wearing the armour. Known body armour has external pockets loosely containing anti-ballistic plates to provide enhanced protection for vital organs. For example, a plate may be located in front of the chest. The or each plate can be a composite formed by an anti-ballistic ceramic tile having a backing of aramid or glass fibre material. When the armour is worn the fabric layers, in adopting the body shape, take on a curved shape to which a flat plate extends tangentially. Thus, there are large portions of the rear face of the flat plate which face the fabric layers but are not in contact therewith. For example, quite wide marginal strips of the rear face are spaced from the fabric layers, and so those strips are unsupported. This means that a bullet striking a part of the front face of the plate opposite such an unsupported strip has a greater chance of shattering the tile in a manner which increases the risk of the bullet passing through the remainder of the armour behind the plate, to injure the person. To reduce this risk, plates incorporating tiles of curved cross-section have been used. That curvature for a given plate is fixed and may not be complementary to the curvature of the textile layers in armour worn by any particular person. So again parts of the plate are spaced from the layers and are thus unsupported. Therefore the defect occurring when the plate is flat can also occur when the plate is curved. Furthermore, when the armour is being tested, for its bullet stopping effectiveness, it is often spread over a sand-bag which causes the fabric layers to lie flat and become spaced from the central part of the curved plate. This results in the central part of the plate being more liable to shatter in a manner admitting greater penetration of the armour than would probably occur when the armour is being worn. Therefore the result of the test can give an unfairly low estimation of what the true effectiveness of the armour would be when in actual use. Another disadvantage of the known body armour is that the loose plate may be disposed wrong way round in the pocket, or the plate may get lost. Both of these can have disastrous consequences for the person wearing the armour.

An object of the invention is to provide a protective shield which if used as body armour avoids or at least mitigates the aforementioned

disadvantages, but which shield is not necessarily limited to usage as body armour.

According to the invention a protective shield which in use is disposed before a person or thing to be protected from injury by a bullet or other missile, comprises an anti-ballistic ceramic tile, a plurality of superposed layers of anti-ballistic textile fabric which when the shield is in use are disposed between the person or thing being protected and the tile, portions of at least some of said layers being adhesively bonded together to form a stiff region to which the tile is attached and supported by said region over an area at least substantially equal to the whole of that face of the tile facing the layers and one or more layers of the fabric extending beyond said region forming a flexible arrangement to adapt to a non-planar shape against which the flexible arrangement may be placed when the shield is in use.

The anti-ballistic textile fabric, which may be woven can be formed from aramid fibres.

The anti-ballistic ceramic tile may be of hard-brittle material and may be any kind known per se. For example, the tile may be formed from alumina, silicon carbide, or boron carbide. The tile may have a hardness in the range of 2000 to 3500 Kg/mm² and a rupture modulus in excess of 400 MN/m². The alumina tile may be of SINTOX (Trade Mark) sold by Smiths Industries Limited.

The tile may be flat or may be non-planar and have a shaped, for example, curved, cross-section. If desired a plurality of tiles may be used. In this latter case the tiles may be relatively small, and may be disposed side by side to form a larger relatively continuous tiled area.

To reinforce the support provided by the stiff region a plate of metal which may be hard may be disposed between the tile and the stiff region and held in place by adhesive. The metal may be steel which may be hardened, aluminium alloy, or titanium. The plate may extend over at least substantially the whole of the area of the face of the tile facing the stiff region.

To augment the support provided by the stiff region, a stiff additional support may be provided adhered to the stiff region and interposed between the tile and region. This additional support may have an area facing the tile at least substantially equal to that of the tile face. The additional support may comprise further superposed layers of anti-ballistic materials adhered together. The further layers may be of or comprise fibres, for example, one or more of the layers may be of aramid or glass fibres, which may be in the form of a textile fabric which may be woven. If desired one or more of such further layers may be interposed between the first-mentioned layers adhered to form the stiff region.

The aramid fibres used have high tensile strength and high stretch resistance. The aramid fabric which can be closely or relatively coarsely woven may be formed of aramid fibre KEVLAR 29 or KEVLAR 49 (Trade Mark of Du Pont) sold by Fothergill & Harvey Limited under their reference D235 and D208 respectively.

The KEVLAR 29 fabric may weigh about 279 gm/m², be about 0.38 mm thick and be of plain weave from warp to weft ends each of about 12.2 per cm, the yarn used being about 1110 decitex.

The KEVLAR 49 fabric may weigh about 218 gm/m², be about 0.33 mm thick, be of plain weave from warp and weft ends each of about 6.7 per cm, the yarn used being about 1580 decitex.

The superposed layers of aramid fabric may be a mixture of KEVLAR 29 and KEVLAR 49 fabrics.

The adhesive(s) used to bond the aforesaid superposed layers and the tile and plate may be of any suitable kind in an adhesive process of any appropriate type.

Liquid or powder adhesive may be used to bond together the superposed layers. The bonding may be by "wet-lay-up" or the layers may be in prepreg form with the adhesive activated by heat and/or other means. Contact adhesive or hot melt adhesive may be used. If desired, the adhesive may be of synthetic resin type, for example, polyester or epoxy resins. The adhesive may also be of a rubber material for example, silicone rubber. If desired the superposed layers may be subjected to pressure during bonding.

The protective shield may be used as or in body armour so the flexible arrangement adopts to the shape of the body of the person wearing the armour. For example, the shield may or form part of a vest or other garment for wear. In the case of body armour a cushion or trauma pack may be provided between the person's body and the layers of anti-ballistic material. The trauma pack may comprise felt for example, a needle pucked felted fabric which may be nylon, and one or more layers of other fabric, for example, aramid fabric which may be as described above.

The protective shield may be placed against objects to protect the latter in which case the flexible arrangement can adopt the shape of the object to fit closely thereto.

One or more layers of the aramid fibre fabric may be disposed in front of the tile, and/or at least one layer of a continuous plastics sheet material may be disposed before the tile. The shield may be in a waterproof cover.

In the flexible arrangement portion(s) of the shield, some or all of the superposed layers may be connected together at intervals in any suitable manner which does not substantially prevent flexibility, for example, by rows of stitching, rivets, staples or of small spots of adhesive.

The invention will now be further described, by way of example, with reference to the accompanying drawings in which:

Fig. 1 is a diagrammatic and partly exploded view of a protective shield formed according to the invention;

Fig. 2 is a diagrammatic and partly exploded view of another embodiment of protective shield formed according to the invention, and

Fig. 3 is a diagrammatic and partly exploded view of a further embodiment of protective shield formed according to the invention.

In the drawings like references refer to like parts.

In Fig. 1, the shield comprises several superposed layers of woven aramid fabric 2 which at the region 4 outlined by dotted line 6 are adhesively bonded together using adhesive 8 so that region 4 is a substantially solid stiff mass supporting an anti-ballistic ceramic tile 10. In Fig. 1 the tile is curved. The whole of its rear face 12 is adhered to the region 4, which, as indicated by outline 14 of the tile thereon, is of greater size than the tile face 12 which is adhered to the stiff region. The portion 16, of the combination of the layers 2 extending beyond the region 4 is a flexible arrangement which can adapt to a shape against which the shield is placed.

In Fig. 2 the tile 10 is flat. Over the stiff region 4 of the bonded layers 2 is an additional support 17 formed by bonded superposed layers 18 of anti-ballistic material forming a substantially solid stiff mass bonded to region 4. The layers 18 may be of the same or different materials, for example aramid fabric or glass fibre fabric or web. The adhesive bonding material is shown at 20. The outline of the tile 10 bonded to the frontmost layer 18 is shown at 14a.

In Fig. 3 the tile 10 is adhesively bonded at 22 to a metal plate 24 bonded at 26 to the additional support 17. Between at least some of the layers 2 in the stiff region 4 are further layers 28 of anti-ballistic material. These layers 28 may be of the same or different materials, for example, aramid fabric or glass fibre fabric or web.

If desired one or more further layers 30 of aramid fabric may be disposed in front of the tile 10. Also a continuous plastics sheet 32 may be disposed in front of the tile 10 (and preferably in front of layers 30) to reduce spall of a missile striking the shield. It being understood that along the direction of travel of a missile to the shield, the tile 10 is in front of the layers 2.

When the shield is used as or incorporated in body armour, a trauma pack 34 may be provided.

When the shield is used in or as body armour, the tile is preferably disposed in front of a particularly vulnerable part of the body, for example, the chest, to protect one or more vital organs.

In addition to the complete support provided by the stiff portion for the tile and the ability of the integral flexible arrangement to adapt to the shape against which it is placed, an advantage of the shield is that the armour to defeat specific high-velocity threats on the tile and low-velocity threats on the flexible arrangement can be determined exactly without the need for excess and redundant ballistic materials within the armour, thus having a saving on weight and cost.

Another advantage of the shield where the support provided for the tile by the stiff portion behind the tile dissipates the remaining kinetic energy from the fragmented impacting bullet or missile, is that this energy is absorbed not only by the high tensile strength of the fibres but by two or more of the bonded layers splitting apart or de-

laminating. For the tile to sustain multi-hits from high velocity missiles it is advantageous that de-lamination is confined to substantially the region directly behind each different part of the tile struck by respective impacting bullets or missiles. The complete support provided by the total adhered mass of the stiff portion further assists the rigid tile around the cone of these impact forces. The rate and extent of de-lamination of the aramid and/or fibre glass layers can be controlled to some extent by the amount and nature of the adhesive and the bond. Thus in an embodiment of the shield formed according to the invention there may be more than one type of adhesive or bonding agent in the make-up of the stiff portion behind the tile.

Another advantage of the shield in accordance with the invention over previously known body armour is that the tile cannot be lost nor when the shield is used in body armour can the tile be located wrong way round when the armour is being worn.

A further advantage of the shield when used as body armour is that it requires fewer waterproof bags and less pockets to contain plates than previously known flexible body armour.

CLAIMS

1. A protective shield which in use is disposed before a person or thing to be protected from injury or other missile, comprising an anti-ballistic ceramic tile, a plurality of superposed layers of anti-ballistic textile fabric which when the shield is in use are disposed between the person or thing being protected and the tile, portions of at least some of said layers being adhesively bonded together to form a stiff region to which the tile is attached and supported by said region over an area at least substantially equal to the whole of that face of the tile facing the layers, and one or more layers of the fabric extending beyond said stiff region forming a flexible arrangement to adapt to a non-planar shape against which the flexible arrangement may be placed when the shield is in use.

2. A shield as claimed in claim 1, in which the textile fabric is aramid fabric.

3. A shield as claimed in claim 1 or claim 2, in which the tile is planar or non-planar.

4. A shield as claimed in claim 3, in which the tile is made from alumina, silicon carbide, or boron carbide.

5. A shield as claimed in any one preceding claim, in which the tile is attached in position by adhesive.

6. A shield as claimed in any one preceding claim, in which instead of said tile there is a tiled area formed by a plurality of smaller anti-ballistic tiles mounted side-by-side.

7. A shield as claimed in any one preceding claim, in which a metal plate attached in position is interposed between the tile and the stiff region.

8. A shield as claimed in claim 7, in which the plate is formed of steel, an aluminium alloy, or titanium.

9. A shield as claimed in any one preceding claim, in which a stiff additional support between the tile or tiled area and the stiff region is adhered to said stiff region, and said additional support does not extend substantially beyond the boundary of the stiff region.

10. A shield as claimed in claim 9, in which the additional support is formed of layers of anti-ballistic textile material adhesively bonded together.

11. A shield as claimed in claim 10, in which one or more of the layers of said textile material in the additional support is/are of aramid fibres or glass fibres.

12. A shield as claimed in any one preceding claim, in which one or more further layers of anti-ballistic textile material is disposed between at least some of said layers of the anti-ballistic textile fabric at said stiff region.

13. A shield as claimed in claim 12, in which one or more of said further layers is formed of aramid fibres or glass fibres.

14. A shield as claimed in any one preceding claim, in which the adhesive bonding of one of said textile layers to another adjacent thereto is different to the adhesive bonding of another said textile layer to an adjacent said textile layer.

15. A shield as claimed in any one preceding claim, in which at least one layer of aramid textile fabric is disposed in front of the tile or tiled area.

16. A shield as claimed in any one preceding claim, in which a continuous plastics sheet material is disposed in front of the tile or tiled area.

17. A shield as claimed in any one preceding claim within a water-proof cover.

18. A shield as claimed in any one preceding claim, in which a cushion or trauma pack is disposed between said superposed layers of anti-ballistic textile fabric and person or thing to be protected.

19. A shield as claimed in claim 18, in which the cushion or trauma pack comprises felt.

20. Body armour for wear in the form of a garment formed by or comprising a shield as claimed in any one preceding claim.

21. A shield as claimed in claim 1 and substantially as hereinbefore described.

New claims or amendments to claims filed on 19 Jan. '84.

Superseded claims: Claim 1.

New or amended claims:—

1. A protective shield which in use is disposed before a person or thing to be protected from injury by a bullet or other missile, comprising an anti-ballistic ceramic tile, a plurality of superposed layers of anti-ballistic textile fabric which when the shield is in use are disposed between the person or thing being protected and the tile, portions of at least some of said layers being adhesively bonded together to form a stiff region to which the tile is attached and supported by said region over an area at least substantially equal to

the whole of that face of the tile facing the layers,
and one or more layers of the fabric extending
beyond said stiff region forming a flexible

5 arrangement to adapt to a non-planar shape
against which the flexible arrangement may be
placed when the shield is in use.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1984. Published by the Patent Office,
25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.